PROJECT ANALYSIS AND INTEGRATION AREA

INTRODUCTION

The objective of the Project Analysis and Integration Area (PA&I) is to support the planning, analysis, integration, and decision making activities of FSA. Accordingly, PA&I supports the Project by developing and documenting Project plans based, in part, on the technical and economic assessments performed by PA&I of the various technical options. Goals for module technical performance and costs, derived from National Photovoltaics Program goals, are established by PA&I for each of the major technical activities in the Project. Assessments of progress toward achievement of goals are made to guide decision making within the Project.

SUMMARY OF PROGRESS

Technology Update

Based on the most recent process descriptions made available for Westinghouse, new cost estimates were prepared for the production of dendritic web modules. The Solar Array Manufacturing Industry Costing Standards (SAMICS) computer program cost estimate was $\$1.02/W_p$ (1985 dollars) for 13.7% efficient modules manufactured in a 25 MW/year production facility.

Sensitivity studies were carried out using Standard Assembly-Line Manufacturing Industry Simulation (SAMIS) to investigate the impact of technical developments within several areas of the dendritic web program. One finding was that continued research on the web growth process was necessary for the project to reach its objectives. Improved web growth rates are necessary if the technology is to be competitive with conventional energy sources. Another finding was that a new combined junction formation process resulted in cost savings in the area of cell processing. JPL-sponsored research to lower the cost of solar-grade silicon promises to further reduce the cost of this solar cell technology.

An updated estimate of Cz module production cost was prepared using state-of-the-art processing technology. Estimated production costs for a 25 MW factory were $\$1.45/W_p$ (1985 dollars), assuming a module efficiency of 13.5%.

The status of crystal silicon PV technology was presented at the 26th PIM in April 1986. The presentation is summarized in the proceedings section of this document. The methodologies which have been developed by PA&I for assessing the status of the technology were also covered in the presentation. The methodologies discussed in the presentation were SAMIS, SIMRAND, and Lifetime Cost and Performance (LCP). Examples were given that showed how each methodology was used in assessing specific aspects of PV technologies. A handout was prepared for the meeting that summarized the capabilities of each of these models, illustrated their application in assessing PV technologies, and indicated the current status and availability of each model.

Software Development

SAMIS

The SAMIS model has been completely converted to run on the IBM PC/XT (or compatible system). The implementation includes three modes of operation: SAMIS, Standard Assembly-Line Manufacturing Price - Estimation Guideline (SAMPEG), and Improved Price Estimation Guidelines (IPEG). The SAMIS mode provides the most detailed analysis of production costs. A hypothetical factory is "built" based on a detailed set of manufacturing process descriptions provided by the user. The cost of labor along with materials, building space, and utilities are taken from a supporting cost account catalog. A detailed financial model is applied to determine the annual costs of operation. An extensive set of output reports, including year-by-year financial reports for the company, are made available by SAMIS.

SAMPEG is a simplified version of SAMIS and is the usual way to run the program. SAMPEG runs in a few minutes, but the reports available are less detailed than SAMIS results. They consist of a summary cost estimate for the modeled company and each of its manufacturing processes.

IPEG is a linear approximation of the more detailed model of the firm constructed by SAMIS. Overhead factors are applied to direct input costs to arrive at total cost. IPEG is particularly useful for investigating the effects of changes in financial parameters on cost estimates prepared by more detailed SAMIS runs. Price estimates calculated with either IPEG or SAMPEG will approximate a SAMIS estimate.

Copies of the PC version of SAMIS and supporting documentation can be obtained through the Computer Software Management and Information Center (COSMIC) located in Athens, Georgia.

SIMRAND

Three JPL documents have been published: The SIMRAND Methodology: Theory and Application for the Simulation of Research and Development Projects, JPL 85-98; The SIMRAND I Computer Program: Simulation of Research and Development Projects, JPL 85-96; and The RANDOM Computer Program: A Linear Congruential Random Number Generator, JPL 85-97. The computer code and the three documents have been submitted to COSMIC (NASA's software dissemination center).

SIMulation of Research ANd Development Projects (SIMRAND) is a decision making methodology for selecting the best course of action in the uncertain environment of R&D projects. SIMRAND makes it posible to model complex decisions involving a number of alternative paths. One or more points along each path can be described as random variables with a range of possible outcomes.

SIMRAND has been used successfully to compare the outlook for competing silicon solar cell technologies. SIMRAND has also been used to rank small solar thermal systems on the basis of cost, and to rank alternative designs for autonomous spacecraft at JPL.

ADDITIONAL ACTIVITIES

Process Cost Estimation Using Basic Processing Units

Earlier studies of manufacturing processes for the production of advanced PV modules have been updated and expanded to reflect more recent technological developments. These basic processing units (BPUs) are manufacturing process descriptions and cost estimates that cover example processes likely to be used in the commercial production of PV modules. The BPUs are not an exhaustive set of all possible combinations of manufacturing equipment and processes, but provide a place to start when examining an immature or ill-defined manufacturing facility of the future.

BPUs provide a baseline understanding of the resources required by various manufacturing processes used in PV module production. Each BPU provides information on the equipment used by the process including estimates of the output rate, cost, and lifetime. Also, floor space, direct labor, and material and utility inputs to the process are described. Cost estimates included with each BPU can be summed to provide rough estimates of the cost of various production sequences for PV modules. In addition, the BPUs can be used as a source of information for engineering cost studies. The SAMIS Computer program, which is an engineering cost model, was used to prepare the production cost estimates for each BPU.

Cherry Hill Revisited

A paper was presented at the IEEE Photovoltaic Specialists Conference (held in Las Vegas, Nevada, October 21-25, 1985), tracing the beginning of the FSA Project as part of the emerging National Photovoltaics Program to the present. The paper covered many of the highlights of the Project as measured by progress toward the Program goals. The original goals for the DOE National Photovoltaics Program were established as an outcome of the Cherry Hill, New Jersey, Conference (in 1973) on Photovoltaic Conversion of Solar Energy for Terrestrial Applications. It was envisioned that a $\$0.50/W_p$ price (1975 dollars), a 10% module level efficiency, and a 20-year lifetime were needed to be competitive with fossil-fuel generated, grid-supplied electricity. The paper reconstructs the details of the original goals and objectives for crystalline silicon technology and concludes with an economic comparison to the 1985 state-of-the-art Cz PV module technology.

The paper concluded that Cz technology essentially meets the Cherry Hill goals. Because current program goals are much more demanding than the original goals, further technology development efforts will be required if they are to be met. Further reductions in wafer costs were identified as the principal technical barrier to the technology reaching current national program goals.